Device SEE Susceptibility Update: 1996-1998

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Abstract

This eighth Compendium continues the previous work of Nichols, et al, on single event effects (SEE) first published in 1985. Because the Compendium has grown so voluminous, this update only presents data not published in previous compendia.

I. Introduction

SEE test programs have continued for several years at the Jet Propulsion Laboratory (JPL), Aerospace Corporation, (ARSP) Goddard Space Flight Center (GSFC), and the European and French Space Agencies (ESA and CNES) to assess device susceptibility to heavy ion and/or proton environments. More recently, organizations such as Space Electronics, Inc (SEI), Matra-Marconi Space (MMS) and Saab have been making significant contributions in this research area. Seven compendia have been published since 1985 in the IEEE Transactions on Nuclear Science [1, 2, 3, 4] and the Radiation Effects Data Workshop Records [5, 6, 7].

II. Testing Approaches

The testing approaches used by all these organizations, while similar, are not identical. Additionally, all these techniques are constantly evolving and moving more and more to computer-control. In general, the testing procedures follow those outlined in the ASTM F1.11 or JEDEC 13.4 documents [10, 11] on single event testing.

III. Data Organization and Scope

This paper summarizes single event upset (SEU) and latchup (SEL) data from 1996 to 1998 from numerous sources. Some additional data from earlier years has come to light and is also included. Single event gate rupture (SEGR) or burnout (SEB) of power transistors is not included, but has previously been presented in the Radiation Effects Data Workshop Records [12, 13, 14]. There is also a limited set of published SEE data using neutrons [15, 16], but because of the paucity of data, this is not included here.

The data reported in the tables is substantially abbreviated, generally including only thresholds and saturation cross sections, and ignores any statistical features, i.e., the data has been excerpted directly from the referenced reports. Because of different definitions of what constitutes threshold, the user would be advised to review the original reference. Although we have endeavored to provide the user with data source references, because of processing changes it is always advisable to consider a test on the flight lot to be used, particularly if the Compendium shows that a device may be marginal for a given mission.

Previous Compendia versions presented a mixture of heavy ion data, with a few entries on proton testing. Because of the significant amount of work performed in the past few years with proton accelerators, this data has been separated out into separate tables. Table 1 shows data from heavy ion testing while Tables 2 and 3 show proton data. The Compendium layout from previous years has also been somewhat modified to make it easier to use. In addition to dividing heavy ion and proton data into separate tables, other significant changes were removal of latchup information from the remarks and placing it into separate columns, thus providing more comprehensive data sets. These changes allow the user to quickly scan a row and, where it exists, get both upset and latchup phenomena data.

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IV. Heavy Ions

Because of the interest in using commercial-off-the-shelf (COTS) devices in space, the bulk of the work in recent years has been done on this class of parts. Designers are particularly interested in these devices because of their capabilities and speed, which are typically superior to most "rad-hard" devices. Foremost in most modern-day designs is the desire for massive amounts of data collection. To this end, much of the more recent testing has concentrated on high-density memories, FPGAs and 32-bit microprocessors.

The desire for reliability has also fostered a higher interest in SEL rather than SEU. Upsets can usually be ameliorated with proper software or hardware design [17], but a SEL failure can result in loss of an entire mission. It is recognized that SEL susceptibility can have a strong temperature dependence, but this data is often not presented in the original reference. Whenever temperature information is noted in the reference, this data is shown in the remarks column.

V. Protons

As COTS devices get smaller and require less charge to initiate an upset, they are trending toward an increased sensitivity to protons that can be in the form of SEU, SEL, single event transients (SET) or displacement damage. Recent data has shown that some optical devices, such as some optocouplers or infrared LEDs, are quite vulnerable to proton-induced upset, latchup or degradation. This is evidenced by the amount of optocoupler data in Table 2, as well as on-orbit SET data from the Hubble Space Telescope [18] and optocoupler degradation on the TOPEX-Poseidon spacecraft [19].

Recent data (Table 3) has also shown that many optoelectronic and bipolar linear circuits may be very vulnerable to proton-induced displacement damage. While not technically a SEE, this data has been included here for completeness.

VI. Conclusions

The latest available SEE data on microcircuits has been gathered and placed into general categories. Data on proton displacement damage in selected device types is also presented.

VII. References

[1] D.K. Nichols, et al, "Trends in Parts Susceptibility to SEU from Heavy Ions", IEEE Trans. Nuc. Sci., NS-32, No. 6, pg. 4189 (Dec. 1985).

[2] D.K. Nichols, et al, "Recent Trends in Parts SEU Susceptibility from Heavy Ions", IEEE Trans. Nuc. Sci., NS-34, No. 6, pg. 1332 (Dec. 1987).

[3] D.K. Nichols, et al, "Latest Trends in Parts SEP Susceptibility from Heavy Ions", IEEE Trans. Nuc. Sci., NS-36, No. 6, pg. 2388 (Dec. 1989).

[4] D.K. Nichols, et al, "Update on Parts SEE Susceptibility from Heavy Ions", IEEE Trans., Nuc. Sci., NS-38, No. 6, pg. 1529 (Dec. 1991).

[5] D.K. Nichols, et al, "Overview of Device Susceptibility from Heavy Ions", 93IEEE Radiation Effects Data Workshop Record, pg. 1, (1993).

[6] D.K. Nichols, et al, "Trends in Device Susceptibility from Heavy Ions", 95IEEE Radiation Effects Data Workshop Record, pg. 1, (1995).

[7] D.K. Nichols, et al, "Device SEE Susceptibility from Heavy Ions (1995-1996)", 97IEEE Radiation Effects Data Workshop Record, pg. 1, (1997).

[8] R. Koga, et al, "SEU Test Techniques...", IEEE Trans. on Nuc. Sci., NS-35, No. 6, pg. 1638 (Dec. 1988).

[9] D.K. Nichols, et al, "Full Temperature Characterization of Two Microprocessor Technologies", IEEE Trans. on Nuc. Sci., NS-35, No. 6, pg. 1619 (Dec. 1988).

[10] ASTM F1192M-95, "Standard Guide for the Measurement of SEP Induced by Heavy Ion Irradiation of Semiconductor Devices", ASTM, 1919 Race St., Philadelphia, Pa. 19103.

[11] JEDEC JESD57, "Test Procedure for the Management of Single-Event Effects in Semiconductor Devices from Heavy Ion Radiation (JC-13.4)", EIA/JEDEC 2500 Wilson Blvd, Arlington, VA, 22201-3834

[12] D.K. Nichols, et al, "Observations of Single Event Failure in Power MOSFETs", 94IEEE Radiation Effects Data Workshop Record, pg. 41, (1994).

[13] D.K. Nichols, et al, "Update of Single Event Failure in Power MOSFETs", 96IEEE Radiation Effects Data Workshop Record, pg. 67 (1996).

[14] J.R. Coss, et al, "Compendium of Single Event Failures in Power MOSFETs", 98IEEE Radiation Effects Data Workshop Record, pg. 15, (1998).

[15] M. Ohlsson, et al, "Neutron Single Event Upsets in SRAM-based FPGAs", IEEE Radiation Effects Data Workshop Record, pg. 177, (July 1998).

[16] M.V. O'Bryan, et al, "Single Event Effect and Radiation Damage Results for Candidate Spacecraft Electronics", 98IEEE Radiation Effects Data Workshop Record, pg. 39, (July 1998).

[17] K.A. LaBel & M.M. Gates, "Single-Event-Effect Mitigation from a System Perspective"; IEEE Trans., Nuc. Sci., NS-43, No. 2, pg. 654 (Jun. 1996).

[18] A. Sharma, et al, "On-Orbit Optocoupler Anomaly", EEE Links, July 1997, pg. 19.

[19] G.M. Swift & A.H. Johnston, "Evaluation of the Space Environment on TOPEX-Poseidon and On-Board Failures of Optocouplers", Jet Propulsion Laboratory Report D-14157 (February 1997).

TABLE 1
Heavy Ion SEE Testing - 1996 to 1998

26-Apr-99

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET** Threshold	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
		Analog Switches/MUXs											
GSFC	1840RP	16-channel analog MUX		SEI	>110				1997			BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
		ASICs											
SEI	65C02	ASIC process test	CMOS Fab 1	SEI	>23<27	1.5E-04			Feb-97 Mar-97			BNL UCD	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
		ADC (8-bit)											
GSFC	AD570	Successive Approximation	CMOS	ADI	7	3.0E-04			1996	>52.5		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14.
JPL	HI1276	Flash	ECL (Bipolar)	HAR					Mar-97	>70		BNL	Temp. increased ~32°C to 69°C during test.
SEI	MP7684	20 Megasamples/sec	CMOS	EXR	<11.4	6.0E-02			1997	18 to 26.6		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
JPL	TMC1175C3V20	Video Flash	Submicron CMOS	RAY					Jun-96	25	1.1E-04	BNL	LU rate (GCR) = 5E-03/yr
		ADC (12-bit)											
ESA	AD7893SQ	Serial 5.5 μs conversion time	LC^2MOS	ADI	14	~2.5E-05			1997	>68		CYC	Bee, et al, 98IEEE Wrkshp Rec., pg 58.
GSFC	CS5012	Self-calib., par/serial interface	CMOS	CRY	3.5 TO 4.8				Mar-97	11			LaBel, EEE Links, Vol. 3, No. 1, Mar 97
		ADC (14-bit)											
JPL	AD9240	10 MSPS Binary parallel out	CMOS	ADI					1997	25	6.0E-04	TAM	Miyahira, preliminary JPL internal report.
JPL	AD9243	3 MSPS Binary parallel out	CMOS	ADI					1997	25	6.0E-04	TAM	Miyahira, preliminary JPL internal report.
JPL	ADS-946-2	parallel out	CMOS	DAT					1997	7.7	4.0E-06	TAM	Miyahira, preliminary JPL internal report.
		ADC (16-bit)											
GSFC	7805LPRP	100 KSPS. 100mW max. pwr dissapation. Parallel output	CMOS	SEI	<1.45				1997	~11.4		BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. LU protection circuit test - OK.
SEI	7809LRP	100 KSPS. 100mW max. pwr dissapation. Serial output	CMOS	BUB	18	5.0E-05			Mar-97	19.9	3.0E-05	BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
ESA	AD676AD	Parallel sucessive approx., 10 μs conv. time.	Hybrid, BiMOS II	ADI	~1.8	>5.0E-05			1997	>28		CYC	Bee, et al, 98IEEE Wrkshp Rec., pg 58. Transient and lingering errors recorded.
Ball	AD677	100 KSPS. Serial output	Hybrid; CMOS & BiMOS II	ADI	3.4				Dec-94				
ESA	AD7884AQ	Two pass flash, 5.3 s conversion time	LC^2MOS	ADI	~2	2.5E-03			1997	>68		CYC	Bee, et al, 98IEEE Wrkshp Rec., pg 58.
GSFC	AD976	parallel, internal 2.5 V ref.	BiCMOS	ADI	<3.38				1997	>80		BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. D/C 9723.
JPL	AD9260	Parallel, sigma-delta	CMOS	ADI					1997	7.7	2.0E-05	TAM	Device failed after second latchup.
SEI	ADS7809	100 KSPS. 100mW max. pwr dissapation. Serial output	CMOS	BUB	17.8	9.0E-05			Mar-97	19.4	3.0E-05	BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170. D/C 7550 & 9649.
JPL	ADS-937	Parallel output, low power.	CMOS (hybrid)	DAT					1997	7.7	2.0E-04	TAM	Miyahira, preliminary JPL internal report. All upsets from gate array chip.
		ADC (24-bit)											
JPL	AD7714-3	3.3 V	CMOS/epi	ADI					Jun-97	55	2.0E-05	BNL	LU rate (GCR) = 1.5E-04/yr.

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		DAC (8-bit)											
GSFC	DAC8800	Octal, serial input	Bipolar	ADI	>80				Mar-97	>80			LaBel, EEE Links, Vol. 3, No. 1, Mar 97, pg 5. D/C 9715
		DAC (12-bit)											
GSFC	MX7847TQ	Dual, parallel input	CMOS	MXM	~10				1997	>75		BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39.
		DAC (18-bit)											
GSFC	SP9380			SIP	1.45 to 3.4				1995	37 to 60		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Catastrophic Latchup.
		DC/DC Power Converters											
GSFC	7804		Hybrid	ADA	>37	<1.0E-07			1997			BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39.
GSFC	5690R-D15	Dual output. +15 V	Hybrid	MDI	26.6				1996			BNL	LaBel, et al 97IEEE Wrkshp Rec., pg 14. SEB/SEGR @ LET = 30.7. Destructive condition @ LET = 52.6.
GSFC	AHF2812	Single output, 12 V	Hybrid	ADA	<37 (drop-outs)				1997			BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. ~10 ms drop-outs @ LET = 26.6. Drop-ous @ 50%><83% loads.
GSFC	ASA2805S/CH	Single output, +5 V	Hybrid	ADA	~14 (drop-outs)	~4.0E-05			1997			BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. ~10 ms drop-outs @ LET = 26.6. Drop-outs @ 0% load; <20% w/180 ohm internal resistor; 20% >< 50% w/2 kohm internal resistor.
GSFC	ATW2805S	Single output, +5 V	Hybrid	ADA	<37 (drop-outs)				1997			BNL	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. ~10 ms drop-outs @ LET = 26.6. Drop-outs @ 70%><83% loads.
GSFC	ICL7662MTV-4	Voltage Converter		MXM	59.7					>80		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. SEB/SEGR @ LET = 30.7. Data @ Vcc = 15 V - higher Vcc shows no errors.
GSFC	MCH2805S	Single output, +5 V	Hybrid	ITP	>100							BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. No SEEs @ LET = 100.
GSFC	MD12680	DC/DC Power Converter	Hybrid (proprietary mod)	MDI	30							BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Drop-out required power cycling
		DSP (16-bit)											
ARSP	SMJ320C50GFAM50	Fixed point - SARAM	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	3	1.0E-02			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9711B. Lockup errors begin @ LET = 15.
ARSP	SMJ320C50GFAM50	Fixed point - DARAM	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	3	3.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9711B. Lockup errors begin @ LET = 15.
ARSP	SMJ320C50GFAM50	Fixed point - PLU, ALU	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	5	1.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9711B. Lockup errors begin @ LET = 15.
ARSP	SMJ320C50GFAM50	Fixed point - NOP	CMOS, 0.7 μm feature, 6.5 μm epi.	TIX	5	2.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9711B. Lockup errors begin @ LET = 15.
		DSP (32-bit)											
ESA	ADSP-21020KG-133	FPU	CMOS	ADI	7	2.0E-03			1996	29	9.0E-04	BNL	Harboe-Sorensen, et al, RADECS97 Data Workshop, pg 97. D/C 9623, Rev 3 die.
ESA	ADSP-21020KG-120	FPU	CMOS	ADI	5	2.0E-03			1996	16.5	1.5E-02	BNL	Harboe-Sorensen, et al, RADECS97 Data Workshop, pg 97. D/C 94269211/9502, Rev 1.
ESA	ADSP-21020KG-80	FPU	CMOS	ADI	5	2.0E-03			1996	12	3.0E-02	BNL	Harboe-Sorensen, et al, RADECS97 Data Workshop, pg 97. D/C 9211/9528, Rev 1.
ARSP	SMJ320C30GB	NOP, Cache, ALU	CMOS (V.5.3), 6.5 μm epi, min 0.7 μm feature size.	TIX	3	2.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9543. Snapback also observed.
ARSP	SMJ320C30GB	General Register	CMOS (V.5.3), 6.5 μm epi, min 0.7 μm feature size.	TIX	3	7.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9543. Snapback also observed.
ARSP	SMJ320C40HFM-40	NOP	CMOS 50C.21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	1.0E-05			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9546A. Snapback also observed.
ARSP	SMJ320C40HFM-40	Cache	CMOS 50C.21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	3	3.0E-05			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9546A. Snapback also observed.
ARSP	SMJ320C40HFM-40	ALU	CMOS 50C.21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	2.0E-05			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9546A. Snapback also observed.

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ARSP	SMJ320C40HFM-40	General Register	CMOS 50C.21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	7.0E-05			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9546A. Snapback also observed.
ARSP	SMJ320C40HFM-40	RAM	CMOS 50C.21.22, 6.5 μm epi, min 0.7 μm feature size.	TIX	5	2.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 9546A. Snapback also observed.
		FIFOs											
GSFC	6704EV-50	4K x 9	CMOS	MTA	see remarks				1997			BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/C 9636. LETth ~ 3 (byte errors); ~ 8 (control errors); ~ 35 (mode change)
GSFC	M6720EV-50	4K x 9	SCMOS/epi RT	MTA	37.1				1996	64.7		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14.
		FPGAs											
SEI	10009L	50k Gate reprogammable PLA	CMOS	GTF					Jan-97 Oct-97	7.7 to 12	3.0E-02	UCB TAM	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
GSFC	3090A	9000 equiv. 2-input gates	CMOS	XIL	4 to 7				1996	4 to 7		BNL	LaBel, EEE Links, Vol. 3, No. 1, Mar 97 & 97IEEE Wrkshp Rec. pg 14. Bit errors.
SAAB	A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	10			2.5E-07	1997	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. S-module errors.
SAAB	A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	10			2.0E-07	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. I/O-module errors.
SAAB	A1280XL (5.0 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	28			8.0E-07	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. C-module errors.
SAAB	A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	5			3.5E-06	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. S-module errors.
SAAB	A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	5			2.5E-06	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. I/O-module errors.
SAAB	A1280XL (3.3 V)	8000 equiv. 2-input gates	CMOS (0.6 μm).	ACT	20			2.0E-06	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9709. C-module errors.
GSFC	A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	8				1996			BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. S- & I/O-module errors.
GSFC	A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	21				1996			BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. C-module errors.
GSFC	A1460A	6000 equiv. 2-input gates	CMOS?epi (1.0 μm featire size)	ACT	6 to 8				1996			BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. S- & I/O-module errors.
GSFC	A1460A	6000 equiv. 2-input gates	CMOS?epi (1.0 μm featire size)	ACT	25 to 30				1996			BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. C-module errors.
GSFC	A32140DX	14000 gates	CMOS, 3200DX family	ACT					1997	>75		BNL	Katz, EEE Links, Vol. 3, No. 3, pg 16, Sep 1997.
SAAB	A32140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	10			2.0E-06	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. S-module errors.
SAAB	A32140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	20			2.0E-06	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. I/O-module errors.
SAAB	A32140DX (5.0 V)	14000 gates	CMOS, 3200DX family	ACT	30			8.0E-07	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. C-module errors.
SAAB	A32140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	5			3.0E-06	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. S-module errors.
SAAB	A32140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	5			2.5E-06	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. I/O-module errors.
SAAB	A32140DX (3.3 V)	14000 gates	CMOS, 3200DX family	ACT	15			2.0E-06	1996	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9703. C-module errors.
GSFC	A32200DX	20000 gates	CMOS, 3200DX family	ACT					1997	11	1.5E-05	BNL	Katz, EEE Links, Vol. 3, No. 3, pg 16, Sep 1997. No saturation @ LET = 52.
GSFC	CLAy-31	3134 equiv. Gates	RAM-based GaAs.	NSC	5					>90		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Data errors.

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GSFC	CLAy-31	3134 equiv. Gates	RAM-based GaAs.	NSC	11					>90		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Reconfiguration/snapback errors.
GSFC	KJ911		Rad-hard, 2 µm epi (3.0 V)	LMA	18.8	~1.5E-06			'96-'97			BNL	Katz, EEE Links, Vol. 3, No. 2, Jun 97, pg 24.
GSFC	MKJ911		CMOS, 10 µm epi (3.0 V)	MAT	13.2	3.0E-06			'96-'97			BNL	Katz, EEE Links, Vol. 3, No. 2, Jun 97, pg 24.
GSFC	MKJ911		CMOS, 10 µm epi (3.3 V)	MAT	18.8	~1.5E-06			'96-'97			BNL	Katz, EEE Links, Vol. 3, No. 2, Jun 97, pg 24.
GSFC	QYH580 LPGA	35000 gates (3.3 V)	Bulk CMOS, 0.8 µm features.	YAM	~ 37	2.0E-06			Feb-97	>70		BNL	Katz, EEE Links, Vol. 3, No. 2, Jun 97, pg 21.
GSFC	QYH580 LPGA	35000 gates (5.0 V)	Bulk CMOS, 0.8 µm features.	YAM	~ 37				Feb-97	~67	4.0E-05	BNL	Katz, EEE Links, Vol. 3, No. 2, Jun 1997, pg 21. LU X-section @ LET = 78. LU @ 60 with 5.5 V.
SAAB	RH1280 (5.0 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8µm	ACT	30			4.5E-07	1997	>110		CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9617. C-module errors.
SAAB	RH1280 (5.0 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8µm	ACT	10			1.5E-07	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9617. S- & I/O-module errors.
SAAB	RH1280 (3.3 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8µm	ACT	25			8.0E-07	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9617. C-module errors.
SAAB	RH1280 (3.3 V)	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8µm	ACT	8			2.0E-06	1997			CYC	Mattson, et al, SAAB Doc. SE/REP/0078/K, 10/97. D/C 9617. S- & I/O-module errors.
LMC	XC4036XL	36000 equiv. gates.	CMOS/7 µm epi, 0.35 µm (3.3 V).	XIL	<15				1997	>100		BNL	Lum, LMC Tech Memo TM26-98. 125° C. Upsets mainly in "basement" (control) logic.
		Gate Arrays/PALs/PLAs											
SEI	10050LPRP	50k Gate reprogammable PLA	CMOS	HTC	11	3.7E-03			1997	>25	3.2E-03	BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170
SEI	22V10FRP	Reprogammable PLA	CMOS	HTC	<11	7.5E-05			1997	>80		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170
SEI	22V10RP	PLA	CMOS	HTC	<3	4.5E-04			1997	>117		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170
GSFC	22V10RPFE	PLA	CMOS	SEI	<3.38				1997	>72.9		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/Cs XC34908493, XC 34950484 and 002611202. F/F errors.
GSFC	22V10RPFE	PLA	CMOS	SEI	~10				1997	>72.9		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/Cs XC34908493, XC 34950484 and 002611202. Combinatorial errors.
GSFC	HX2300	SOI Test Metal	RICMOS SOI4	HON	>120				1995	>120		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
GSFC	IMP50E10	Electrical programmable Analog Circuit	CMOS	IMP	1.45				1997	15 to 26.6		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
		Line Drvr/Rcvr/Xcvr											
GSFC	54ABT245	Octal Transceiver	BiCMOS	NSC	>100				1997	>100		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
GSFC	54ABT245	Octal Transceiver	BiCMOS	PHL	>100				1997	>100		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
JPL	74LVQ244	Buffer/epi (3.3 V)	CMOS	NSC					Apr-96	>120		BNL	
GSFC	AM7968 & AM7969	TAXI Transmitter & Receiver	Bipolar	AMD	<3.4				1996	>53		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Data and synch errors. Synch errors required power reset.
MMS	AM79C98	Twisted Pair Transceiver	CMOS	AMD	>42				1995	50		GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9545. LU cross section @ LET=82.
MMS	DP8392CV	Coaxial Transceiver Interface	Bipolar, low power Schottky, junction isolated	NSC	~1	2.0E-13			1995	>60		GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9545. Transmit mode. Errors normalized/transmitted bit.
MMS	DP8392CV	Coaxial Transceiver Interface	Bipolar, low power Schottky, junction isolated	NSC	~1	2.0E-14			1995	>60		GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9545. Receive mode. Errors normalized/transmitted bit.

TABLE 1
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Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET** Threshold	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
JPL	LV244	Octal Buffer/driver (3 V)	CMOS	PHL					Apr-96	>120		BNL	Tested @ 90° C.
JPL	LVC245	Octal bidirectional buffer	CMOS	PHL					Apr-96	85		BNL	Latchup current > 50 Ma.
GSFC	MIC4429AJB	Linear Driver		MIC	>84.7				1997	>84.7		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No memory elements.
GSFC	SNJ54ABT245AJ	Octal Buffer/driver	CMOS	TIX	>100				1997	>100		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
GSFC	UT63M147-BPC	1553 Transceiver	CMOS	UTM	11				1996	>35		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14.
		Logic Devices											
JPL	CD4014	Shift Register	CMOS	HAR	>120				Apr-96			BNL	Tested @ 125° C. D/C 9403. Test of newer vintage CD4xxx family.
		SRAMs											
NASDA	93419	512-bit	Bipolar	FSC?									Shimano, et al, 91IEEE TNS, Vol. 38, N0. 6, pg 1693
GSFC	68128	128K x 8	CMOS (1.0 µm) w/NMOS periph.	HTC	1.45				1995	>60		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Address errors.
GSFC	68128	128K x 8	CMOS (1.0 µm) w/NMOS periph.	HTC	3.38				1995	>60		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Bit errors.
GSFC	68128	128K x 8	CMOS (1.0 µm) w/NMOS periph.	HTC					1995	>60		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Address errors.
NASDA	µPD4464D-20	2K x 8	CMOS	NEC					1997	4.56	2.4E-01	var.	Goka, et al, 98IEEE TNS, Vol. 45, No. 6, pg 2771.
SEI	32C408	512K x 8	CMOS	SEI	3.3	3.5E-05			1997	>117		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
NASDA	38510/19101XCR	64K	CMOS/epi	NEC	16.6	6.4E-02		1.0E-06	1997	>70		TIARA	Goka, et al, 98IEEE TNS, Vol. 45, No. 6, pg 2771.
NASDA	38510/92001XB	256K	CMOS	HTC	7.2	5.1E-02		2.0E-07	1997	>62		var.	Goka, et al, 98IEEE TNS, Vol. 45, No. 6, pg 2771.
GSFC	5C1008FE-M	128K x 8	CMOS	AUS	<3.38	2.0E-01			1997	>50		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Multi-bit errors also seen.
MMS	AS5C4008CW-35E	512K x 8	CMOS/epi, 0.5 µm feature size	MOT	~1			8.1E-07				CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68. D/C 9731. MOT chips packaged by Austin.
GSFC	AS5C512K8	512K x 8	CMOS	AUS	<3.38	1.0E-03			1997			BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Multi-bit errors also seen.
MMS	CXK581000BP-10LL	128K x 8	CMOS	SNY	~2			1.0E-08	1997	>68		CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68.
MMS	HM628128BLP-7	128K x 8	HiCMOS, 0.8 µm features, Rev B.	HTC	~2			3.0E-07	1997			CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68. D/C 9713
MMS	HM628512ALP-7	512K x 8	HiCMOS, 0.5 µm features, Rev B.	HTC	~2			2.0E-07	1997			CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68. D/C 9705
SNL	HM65656	32K X 8	CMOS, 0.8 µm, rad-tolerant	MTA	~1	1.5E-01			1997			BNL	Dodd, et al, 98IEEE TNS Vol. 45, No. 6, pg 2483.
MMS	IS61C1024-20M	128K x 8	CMOS (0.5 µm)	ISS	~2			1.5E-06	1997	>68		CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68.
MMS	KM864002AJ-17	512K x 8	CMOS/epi, 0.5 µm feature, Rev A	SAM	~1			1.0E-07	1997			CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68.
SNL	M65608	128K x 8	CMOS, 0.5 µm, commercial	MTA	~1	1.0E-01			1997			BNL	Dodd, et al, 98IEEE TNS Vol. 45, No. 6, pg 2483.
SNL	M65608E	128K x 8	CMOS, 0.5 µm, rad-tolerant	MTA	~2	8.0E-02			1997			BNL	Dodd, et al, 98IEEE TNS Vol. 45, No. 6, pg 2483.

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SNL	M65964	64K Test Vehicle	CMOS, 1.0 µm, rad-tolerant	MTA	~1	1.0E-01			1997			BNL	Dodd, et al, 98IEEE TNS Vol. 45, No. 6, pg 2483.
MMS	MCM6246WJ20	512K x 8	CMOS/epi, 0.5 µm feat., Rev W51.	MOT	~1			1.0E-07	1997			CYC	Poivey, et al, 98IEEE Wrkshp Rec., pg 68. D/C 9602
SNL	TA786	16K Test Vehicle	CMOS, 0.5 µm, rad-tolerant	SNL	~8	3.0E-03			1997			BNL	Dodd, et al, 98IEEE TNS Vol. 45, No. 6, pg 2483.
		Flash Memories											
JPL	28F016SA	2M x 8 or 16M x 1, NOR	ETOX process	INT	7	1.0E-06 to 1.0E-07			Nov-95	44		BNL	Schwartz, et al, 97IEEE TNS, No. 6, pg 2315. D/C 96??. Functional errors.
JPL	28F016SV	2M x 8 or 16M x 1, NOR	ETOX process	INT	7	1.0E-06 to 1.0E-07			Nov-95	44		BNL	Schwartz, et al, 97IEEE TNS, No. 6, pg 2315. D/C 9524 & 9534. Functional errors.
JPL	KM29N16000	2M X 8 NAND	CMOS	SAM	11	2.0E-04	4000		Mar-97	~60		BNL	Schwartz, et al, 97IEEE TNS, No. 6, pg 2315. D/C 9530. Stuck bits @ LET = 37. All observed upsets probably in peripherals.
JPL	KM29N32000	4M X 8 NAND	CMOS	SAM			64K		Mar-97			BNL	Schwartz, et al, 97IEEE TNS, No. 6, pg 2315. D/C 96??. No stuck bits.
		DRAMs											
GSFC	0116400J1C-70 Rev C	4M x 4	CMOS	IBM	3	7.0E-02			Dec-96	50	2.0E-04	UCB	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Cell errors.
GSFC	0116400J1C-70 Rev C	4M x 4	CMOS	IBM	5	7.0E-02			Dec-96	50	2.0E-04	UCB	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Block errors.
GSFC	0116400J1D	4M x 4	CMOS	IBM	<3.38				1996	>11.5		UCB TAM	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Bit errors.
GSFC	0116400J1D	4M x 4	CMOS	IBM	3.9				1996	>11.5		UCB TAM	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Bit and block errors.
ESA	0117400BT1E-60	4M x 4 (3.3 V)	CMOS (IBM - ES3)	IBM	~1			4.0E-08	1997			CYC	Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.
SEI	14C0164RP	4M x 4	CMOS	HTC	4.5	3.0E-01			Jan-97	>89		UCB TAM	Layton, et al, 98IEEE Wrkshp Rec., pg 170.
JPL	D426S165G5	4M X 16 EDO (5.0 V)	CMOS	NEC	~1			1.0E-15	1998			BNL	Swift, RADECS98 preprint. D/C 9738KE006. X-section without row or column upsets.
JPL	**HM5165165AJ**	**4M x 16 EDO**	**CMOS**	**HTC**	**<20**			**1.0E-06**	**1998**			**BNL**	**Swift, RADECS98 preprint. D/C 9737**
ESA	**HM51W16100B**	**CMOS**	**CMOS**	**HTC**	**~1**			**8**	**1997**			**CYC**	**Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.**
ESA	HM51W16100B	4M x 4 (3.3 V)	CMOS	HTC	<1	1.3E+00		8.0E-16	1997			CYC	Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.
ESA	KM44V4100AJ	4M x 4 (3.3 V)	CMOS	SAM	<1	4.8E-01		3.0E-16	1997			CYC	Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.
JPL	KM48V8104AS-6	8M x 8 EDO	CMOS	SAM	~1	1.3E+00		2.0E-16	1997			BNL	Swift, RADECS98 preprint. D/C 9737. Cross section without row or column upsets.
GSFC	M1611D2 (Seimens 1994)	4M x 4 (3.3 V)	CMOS	IBM ES3					1997			PSI	Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.
ESA	MT4LC4M4D42 Rev T	4M x 4 (3.3 V)	CMOS	MCN	~1			6.0E-08	1997			CYC	Harboe-Sorensen, et al, 98IEEE Wrkshp Rec., pg 74.
JPL	TC5165805AFT-50	8M x 8	CMOS	TOS	~1	1.0E-08			1998			BNL	Swift, RADECS98 preprint. D/C 9721. Cross section without row or column upsets.
GSFC	TMS416400DJ-60	4M x 4	CMOS	TIX	<2.5				1996	>65		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14. Bit errors.
		EEPROMs											
GSFC	28C010TE	128K x 8	CMOS	HTC	>69				1997	>69		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Static mode testing.

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Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET** Threshold	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 26-Apr-99
GSFC	28C010TE	128K x 8	CMOS	HTC	~20				1997	>69		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Programming mode testing. Byte errors @ LET ~20; Block errors @ ~25; Stuck bits @ ~59.7.
GSFC	57C256F-35		CMOS	WSI					1997	<18.8		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/C 9718
GSFC	AS58C1001SF-15E	1 Mbit	CMOS	HTC	>37				1997	>37		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/C 9646. Static mode testing.
GSFC	AS58C1001SF-15E	1 Mbit	CMOS	HTC	~18.8				1997	>37		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Programming mode testing. Block errors and one stuck bit @ LET = 37.
GSFC	E28F016SB	1M x 16 Flash	CMOS	INT	9 to 11.4					26.2 to 29.9	1.0E-06	BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
		Microprocessor (16-bit)											
ARSP	MG80C186-12/B	NOP	CMOS III	INT	10	3.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8951. Lockup errors begin @ LET = ~10.
ARSP	MG80C186-12/B	ALU, Bus Unit	CMOS III	INT	10	2.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8951. Lockup errors begin @ LET = ~10.
ARSP	MG80C186-12/B	General register	CMOS III	INT	10	7.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8951. Lockup errors begin @ LET = ~10.
ARSP	MG80C186-12/B	Segment register	CMOS III	INT	10	5.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8951. Lockup errors begin @ LET = ~10.
ARSP	MG80C286-12/883	NOP, ALU	CMOS/epi	HAR	10	5.0E-04			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8936. Lockup errors begin @ LET = ~5.
ARSP	MG80C286-12/883	General register	CMOS/epi	HAR	10	1.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8936. Lockup errors begin @ LET = ~5.
ARSP	MG80C286-12/883	Segment register	CMOS/epi	HAR	10	7.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8936. Lockup errors begin @ LET = ~5.
ARSP	MG80C286-12/883	Bus Unit	CMOS/epi	HAR	7	5.0E-03			1997	>63		UCB	Crain, et al, 98IEEE Wrkshp Rec., pg 51. D/C 8936. Lockup errors begin @ LET = ~5.
		Microprocessor (32-bit)											
JPL	6x86-PR166+GP	166 MHz Pentium	CMOS	CYR	1.7	1.0E-04			Dec-97			TAM	JPL internal report. Cross section @ let = 37.
SEI	80486DX2RP	50 MHz test frequency	CHMOS V (0.8 µm), 5.0 V	INT	<5.4	2.0E-03			1997	>40		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170.D/C 9527527C. Cache on.
SEI	80486DX2RP	50 MHz test frequency	CHMOS V (0.8 µm), 5.0 V	INT	<5.4	1.5E-04			1997	>40		BNL	Layton, et al, 98IEEE Wrkshp Rec., pg 170.D/C 9527527C. Cache off.
JSC	80486DX4		3LM CMOS (0.5 µm) - 3.45 V	AMD	1.5	2.5E-03			1996	~5		TAM	Kouba, et al, 97IEEE Wrkshp Rec., pg 48 & JSC Test Report 12/96. Threshold/X-section with cache on. X-section unsat. @ LET = 25. 8 error modes seen.
JSC	80486DX4		3LM CMOS (0.5 µm) - 3.45 V	AMD	4.5	2.5E-03			1996	~5		TAM	Kouba, et al, 97IEEE Wrkshp Rec., pg 48 & JSC Test Report 12/96. Same as previous but threshold/X-section is for cache disabled.
GSFC	H30466A-21		CHMOS IV	SEI	5 to 6				1995	35 to 37.5		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Micro latchup only. Count error cleared by reset.
GSFC	H30466A-21		CHMOS IV	SEI	3.4 to 5				1995	35 to 37.5		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Micro latchup only. Reset errors.
GSFC	H30466A-21		CHMOS IV	SEI	6 to 11.4				1995	35 to 37.5		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Micro latchup only. Lockup cleared by reset.
JPL	K5-PR166ABX	166 MHz Pentium	CMOS (3.5 V)	AMD	<0.4	6.3E-08			Jun-97	0.37	1.3E-06	BNL	Saturated LU cross section ~1.0E-01 cm^2. LU destructive.
JPL	K5-PR166ABX	166 MHz Pentium	CMOS (3.5 V)	AMD	<1.7	6.3E-08			Dec-97	1.7	1.0E-06	BNL	Saturated LU cross section ~2.0E-03 cm^2. LU destructive.
GSFC	MG80486DX2-66		CHMOS V	INT	4.3 to 7.9				1997	26.6 to 37.3		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. D/C 9451. Dynamic tests with and without cache enabled. Both data and lockup SEUs observed. Also microlatches and destructive SEL @ LET >26.6

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GSFC	Mongoose V (R3000)	RISC	CMOS/SOI (Honeywell)	SYN	>83				1997	>96		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Cache off.
GSFC	Mongoose V (R3000)	RISC	CMOS/SOI (Honeywell)	SYN	~40				1997	>96		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Cache on.
GSFC	MQ80386-25/B		CHMOS IV	INT	4 to 5	8.0E-05				30 to 32		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Micro latchup only. Count or lockup cleared by reset.
GSFC	MQ80386-25/B		CHMOS IV	INT	5 to 6	1.5E-03				30 to 32		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Micro latchup only. Lockup cleared by reset.
HON	RH-32	RISC	Honeywell HI Process	HON	~30			4.6E-07	1997	>83		BNL	Leavy, et al, 98IEEE Wrkshp Rec., pg 11.
		Microprocessor peripherals											
GSFC	82C54	Timer	CMOS	INT	9				1995	>80		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
GSFC	D8255A-5	Prog. Peripheral Interface	<3.6	INT					1995	59.6		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
MMS	DP83932CVF	Network Interface Controller	M^2CMOS (1.0 µm)	NSC					1995	15	3.0E-03	GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9442.
MMS	DP83950BVQB	Repeater Interface Controller	M^2CMOS (1.5 µm)	NSC					1995	15	1.0E-03	GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9506.
MMS	DP83956AVLJ	Repeater Interface Controller	M^2CMOS (1.5 µm)	NSC					1995	20	2.5E-03	GANIL GSI	Poivey, et al, 96IEEE Wrkshp Rec., pg 73. D/C 9452.
GSFC	M82C59	Interrupt Controller	CMOS	HAR	11.4				1995	>80		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19.
GSFC	MQ82380-25/B	32-bit Integrated Peripheral.	CHMOS III	INT	3.4				1995	15 to 30		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Reset errors cleared by reset. Microlatches. Also a classic LU or SEE self test.
GSFC	TL7705	Power Supervisor	Bipolar TTL	TIX	3.4 to 4.5	8.0E-05			1996	>30		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14.
GSFC	TL7705-5	Power Supervisor	Bipolar TTL	TIX	7.5 to 11.6	1.0E-04			1996	>65		BNL	LaBel, et al, 97IEEE Wrkshp Rec., pg 14.
		Coprocessor (32-bit)											
GSFC	MG80387-20/B	Math Unit	CHMOS IV	INT	9 to 11.4				1995	32 to 35		BNL	LaBel, et al, 96IEEE Wrkshp Rec., pg 19. Microlatches observed.
		Op-Amp											
ARSP	LM108	General Op-Amp	Bipolar	NSC	2	~5.0E-03			1997	>60		UCB	Koga,et al, 97IEEE TNS, No. 6, pg. 2325. D/C 9533. No LET_{th} dependence on input voltage delta.
ARSP	OP-42	Precision high Speed, fast settling Op-Amp	Bipolar	ADI	2	~2.0E-03			1997	>60		UCB	Koga,et al, 97IEEE TNS, No. 6, pg. 2325. D/C 9630. No LET_{th} dependence on input voltage delta.
GSFC	OP400	Quad, low power, low offset		PMI	20				1997	>80		BNL	Crain, et al, 98IEEE Wrkshp Rec., pg 39. D/C 9711. Transients only. Minimum delta-V = 0.25 V.
		Optocouplers											
JPL	4N49	Single Transistor	890 µm (AlGaAs) lateral	HPA					1997				
JPL	6N140	Darlington Amplifier	700 µm (GaAsP) sandwich	HPA	11				1997			BNL	Johnston, et al, 98IEEE TNS Vol. 45, No. 6, pg 2867.
JPL	HCPL-5203	Hi-Gain Amp.	700 µm (GaAsP) sandwich	HPA	0.3	~3.8E-03			1997			BNL	Johnston, et al, 98IEEE TNS Vol. 45, No. 6, pg 2867. No saturation cross section @ LET = 40.
JPL	HCPL- 5631 (6N134)	Hi-Gain Amp.	700 µm (GaAsP) sandwich	HPA	0.3	~2.6E-03			1997			BNL	Johnston, et al, 98IEEE TNS Vol. 45, No. 6, pg 2867. No saturation cross section @ LET = 30.
GSFC	HCPL-6651	High speed logic output		HPA	<0.03				1997			BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. SET @ LET <0.03
		Other Linears											

TABLE 1
Heavy Ion SEE Testing - 1996 to 1998

26-Apr-99

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET** Threshold	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
JPL	37-97	Autocorrelator	Bipolar	ORB?	3.5	1.8E-06			Sep-98			TAM	Cross section saturation = 3.0E-04 @ LET = 80.
GSFC	AD630	Balanced Modulator	Bipolar	ADI	3.38				1996		>65	BNL TAM	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Short (<20 μs) errors.
GSFC	AD630	Balanced Modulator	Bipolar	ADI	7.4				1996		>65	BNL TAM	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Medium (20 - 100 μs) errors.
GSFC	AD630	Balanced Modulator	Bipolar	ADI	7.4				1996		>65	TAM	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Long (>100 μs) errors.
GSFC	AD652	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	3.0E-03			1996		>64.7	BNL	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Single-bit SEUs.
GSFC	AD652	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	6.0E-05			1996		>64.7	BNL	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Double-bit SEUs.
GSFC	AD652	Voltage-to-Frequency Conv.	Bipolar	ADI	7.4	1.0E-04			1996		>64.7	BNL	LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Multiple-bit SEUs.
GSFC	FUGA 15	Image Driver	CMOS	CCT					1997	11.4 to 12		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
GSFC	QS3384DM	Quickswitch	CMOS	QSI					1995	15 to 18		BNL	LaBel, et al, 96 IEEE Wrkshp Rec., pg 19.
ARSP	SG1549	Current Sense Latch	Bipolar	SLG	5	~3.0E-04			1997	>60		UCB	Koga,et al, 97IEEE NSREC TNS, No. 6, pg. 2325. D/C 9627.
		Voltage Comparators											
ARSP	AD9696	Ultra-fast, 200 ps prop. Delay	Bipolar	ADI	6	2.0E-06 - 1.0E-05			1997	>60		UCB	Koga, et al, 97IEEE TNS, No. 6, pg. 2325. D/C 9605. No LET_{th} dependence on input voltage delta.
JPL	LM111	Single	Bipolar	NSC	<1.45				Apr-96			BNL	Transient test only.
ARSP	LM111	Single	Bipolar	NSC	3 to 40	3.0E-06 - 1.0E-04			1997			UCB	Koga, et al, 97IEEE TNS, No. 6, pg. 2325.. D/C 9619. Very strong LETth dependence on input voltage delta.
ARSP	LM119	Dual	Bipolar	NSC	~3	~1.5E-04			1997			UCB	Koga, et al, 97IEEE TNS, No. 6, pg. 2325. D/C 9535. No LETth dependence on input voltage delta.
JPL	LM139	Quad	Bipolar	NSC	1.7				Apr-96			BNL	Transient test only.
JPL	LM139	Quad	Bipolar	PMI	<1.45				Apr-96			BNL	Transient test only.
GSFC	LM139	Quad	Bipolar	NSC	<10				1997	>37		BNL	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39.
ARSP	LM139	Quad	Bipolar	NSC	3 to 40	1.0E-04 - 3.0E-04			1997			UCB	Koga, et al, 97IEEE TNS, No. 6, pg. 2325.. D/C 9318. Very strong LETth dependence on input voltage delta.
		Voltage References											
GSFC	LM136AH	+2.5 V Reference.	Bipolar	NSC	3.38				1996				LaBel, et al, 97 IEEE Wrkshp Rec., pg 14. Short (<1 μs) errors.
ARSP	REF-02	+5 V Reference	Bipolar	ADI	3 to 6	1.0E-04 - 5.0E-04			1997	>60		UCB	Koga, et al, 97IEEE TNS, No. 6, pg. 2325.. D/C 9305. Weak LETth dependence on input voltage delta.

TABLE 1
Heavy Ion SEE Testing - 1996 to 1998

Test Org.*	Device	Function	Technology	Mfr.	Effective SEU LET** Threshold	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 26-Apr-99
Legend:													
	Manufacturers: ACT = ACTEL, Corp; ADA = Advanced Analog Devices; ADI = Analog Devices, Inc; AMD = Advanced Microdevices Corp; BOE = Boeing Corp;												
	BUB = Burr-Brown Corp; CCT = C-Cam Technology; CYP = Cypress Corp; CYR = Cyrix; DAT = Datel; FOR = Force, Inc;												
	GTF = Gatefield; HAM = Hamamatsu; HON = Honeywell; HPA = Hewlett-Packard; HTC = Hitachi, Ltd; IBM = International Business Machines; IMP = IMP, Inc; INT = Intel Corp;												
	ISS = ISS, Inc; ITP = Interpoint; LMA = Lockheed-Martin; MAT = Matsushita, Corp; MCN = Micron Technologies; MDI = Modular Devices, Inc; MHS = Matra-Harris Semiconductor (France);												
	MOT = Motorola Semiconductor Products; MPC = Micropac, Corp; MXM = Maxim; NEC = Nippon Electric Corp; NSC = National Semiconductor Corp; ONI = Optical Networks, Inc;												
	OPT Optek; ORP = Orbit Semiconductors; PHL = Phillips Laboratories; PMI = Precision Monolithic, Inc; QSI = Quickswitch, Inc; RAY = Raytheon; SAM = Samsung; SCI = SCI Systems;SDL = Spectra Diode Labs;												
	SEI = Space Electronics, Inc;SIE = Siemens Components, IncSGS = SGS-Thompson; SIP = Sipec; SLG = Silicon General, Inc; SNL = Sandia National Laboratories; SNY = Sony Corp; SYN = Synovia; TIX = Texas Instruments;												
	UTM = United Technologies Microelectronics Center; WSI = Western Semiconductor, Inc; XIL = Xilinx Corp; YAM = Yamaha.												
	Test Organizations:				**Radiation Facilities:**								
	Aero = Aerospace Corp., El Segundo, CA				BNL - Tandem Van de Graaff, Brookhaven National Laboratories, Long Island, NY								
	BNL - Tandem Van de Graaff, Brookhaven National Laboratories, Long Island, NY				CYC - CYCLONE, Université Catholique de Louvain-la-Neuve, Belgium								
	BREL = Boeing Radiation Effects Laboratory, Seattle, WA				GANIL - GANIL Accelerator, France								
	CNES = Centre National d'etudes Spatiales, Toulouse, France				GSI - Gesellschaft fur Schwerionenforschung, Darmstadt, Germany								
	ESA = European Space Agency, Noordwijk, Netherlands				PSI - Paul Scheerer Institute, Villigen, Switzerland								
	HON = Honeywell Space Systems, Clearwater, FL				TAM - Texas A&M University Cyclotron Institute, College Station, TX								
	JPL = Jet Propulsion Laboratory, Pasadena, CA				TIARA - Takasaki Ion Accelerators for Advanced Radiation Application, Japan								
	MM = Matra Marconi Space, France				UCB - 88-inch cyclotron, University of California, Berkeley, CA								
	NASDA = National Space Development Agency of Japan, Tokyo, Japan												
	SNL = Sandia National Laboratories, Albuquerque, NM												

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 8-Jun-99
		Bus Controllers/Encoders											
GSFC	UT1553B RTI	Remote Terminal	CMOS Fab I	UTM	var.	>1.0E-09			1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39.
		DC/DC Power Converters											
GSFC	MHF+2815D	Dual output, +15 V IN	Hybrid	ADA	51				1997			LLU	O'Bryan, et al 98IEEE Workshop Record, pg 39.
GSFC	MHF+2815D	Dual output, +15 V IN	Hybrid	ADA	51				1997			IUCF	O'Bryan, et al 98IEEE Workshop Record, pg 39.
		Fiber Optics											
GSFC	2706T	Fiber Channel Link X-mitter	CMOS	FOR	var.				1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Bit and burst errors.
GSFC	2706R	Fiber Channel Link Rcvcr	CMOS	FOR	var.				1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Bit and burst errors.
GSFC	ATTDA204B	Fiber Channel Link X-mitter	CMOS	ATT	var.				1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Bit and burst errors.
GSFC	ATTDA205B	Fiber Channel Link Rcvcr	CMOS	ATT	var.				1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Bit, burst and synch errors.
		FIFOs											
GSFC	M6720EV-50	4K x 9	SCMOS/epi RT	MTA	63			5.6E-14	1996			UND	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	M6720EV-50	4K x 9	SCMOS/epi RT	MTA	197			8.6E-14	1996			IUCF	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	M6720EV-50	4K x 9	SCMOS/epi RT	MTA	197			8.3E-11	1996			IUCF	LaBel, et al, 97IEEE Workshop Record, pg 14. Pointer errors.
GSFC	M6720EV-50	4K x 9	SCMOS/epi RT	MTA	197			2.0E-12	1996			IUCF	LaBel, et al, 97IEEE Workshop Record, pg 14. Control errors.
		FPGAs											
GSFC	A1280	8000 equiv. 2-input gates	CMOS/epi (1.2 µm feature size).	ACT	197				1995			ICUF	LaBel, et al, 96IEEE Workshop Record, pg 19. No upsets..
GSFC	A1280A	8000 equiv. 2-input gates	CMOS/epi ACT 2 (MAT chip) 1.0 µm feat.	ACT	197				1997			ICUF	O'Bryan, et al, 98IEEE Workshop Record, pg 39. S-module upsets
GSFC	A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	var.	1.3E-13			1996				LaBel, et al, 97IEEE Workshop Record, pg 14. S-module errors.
GSFC	A14100A	10000 equiv. 2-input gates.	COS/epi?	ACT	var.	2.8E-14			1996				LaBel, et al, 97IEEE Workshop Record, pg 14. I/O-module errors.
GSFC	A1460A	6000 equiv. 2-input gates	CMOS?epi (1.0 µm featire size)	ACT	var.				1996			BNL	LaBel, et al, 97IEEE Workshop Record, pg 14. S- & I/O-module errors.
GSFC	CLAy-31	3134 equiv. gates	RAM-based GaAs.	ACT	var.					>90		BNL	LaBel, et al, 97IEEE Workshop Record, pg 14. Data and reconfiguration errors.
GSFC	MKJ911	not specified.	CMOS, 10 µm epi (3.3 V)	MAT	196				'96-'97			IUCF	Katz, EEE Links, Vol. 3, No. 2, pg 24, Jun 1997. No upsets
GSFC	RH1280	8000 equiv. 2-input gates	CMOS/epi (rad-hard LMA, 0.8µm	ACT	20-150	~3.0E-05			1996			IUCF	Katz, EEE Links, Vol. 2, No. 2, Jul 1996
SAAB	XC4010E-4	10000 equiv. gates.	CMOS, 0.6µm (5.0 V)	XIL	100			1.3E-15	1997			TSL	Ohlsson, et al. D/C 9612. 178K-bits tested.
SAAB	XC4010XL-4	10000 equiv. gates.	CMOS, 0.35µm (3.3 V)	XIL	100			4.4E-15	1997			TSL	Ohlsson, et al. D/C 9733. 254K-bits tested.
		Gate Arrays/PALs/PLAs											
GSFC	IMP50E10	Elect. Programmable Analog Circ.	CMOS	IMP	197				1997				LaBel, et al, 96IEEE Workshop Record, pg 19.
GSFC	JT22V10-10	PLA	CMOS	CYP	var.				1997			BNL	O'Bryan, et al, 98IEEE Workshop Record, pg 39. F/F upsets. Same die as 22V10RPFE.
		Line Driver/Receiver/Transceiver											
GSFC	DR1773	1773 Bus Transceiver.	CMOS(?)	BOE	var.	1.4E-10			1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Transmit mode. Attenuation and angle dependent.
GSFC	DR1773	1773 Bus Transceiver.	CMOS(?)	BOE	var.	<2.0E-11			1996				LaBel, et al, 97IEEE Workshop Record, pg 14. Receive mode. Attenuation and angle dependent.

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 8-Jun-99
		Logic Devices											
GSFC	54ALS 05	Hex Inverter	Bipolar-LSSTL	TIX	var.				1997				O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SEU.
GSFC	54ALS1035	Hex Non-Inverting Buffer	Bipolar-LSSTL	TIX	var.				1997				O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SEU.
GSFC	54LS 03	Quad 2-input NOR	Bipolar-LSSTL	TIX	var.				1997				O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SEU.
		SRAMs											
GSFC	70V25	8K x 16 Dual Port	CMOS	IDT	26.6 - 63				1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. SBE @ LET = 26.6. No MBE up to LET = 63.
MMS	AS5C4008CW-35E	512K x 8	CMOS/epi, 0.5 μm feature size	MOT	10			1.5E-13				PSI	Poivey, et al, 98IEEE Workshop Record, pg 68. D/C 9731. MOT chips packaged by Austin.
ESA	CXK1000AM-70LL	128K x 8	CMOS	SNY	60			2.2E-14	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 1992
ESA	CXK1000AM-70LL	128K x 8	CMOS	SNY	60			8.7E-14	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 1992
ESA	CXK1000P-10L	128K x 8	CMOS	SNY	500			4.5E-15	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 0714E
MMS	CXK581000BP-10LL	128K x 8	CMOS	SNY	10			3.5E-14	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68.
ESA	CXK58258P-35	32K x 8	CMOS	SNY	30			7.3E-15	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9F04E
ESA	CXK58258P-35	32K x 8	CMOS	SNY	500			3.0E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9F04E
ESA	CY7C167-35DC	16K x 1	CMOS	CYP					Nov-89	209	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8742
ESA	CY7C185-25DC	8K x 8	CMOS	CYP	300			1.3E-12	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9214
ESA	CY7C185-35DC	8K x 8	CMOS	CYP	300			1.4E-12	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9006
ESA	CYC128-35DC	2K x 8	CMOS	CYP	300			2.1E-12	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8852
ESA	CYC128A-35DC	2K x 8	CMOS	CYP	300			1.3E-12	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8847
ESA	D431000ACZ-85LL	128K x 8	CMOS	NEC	300			1.6E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9146
ESA	D43256AC10LL	32K x 8	CMOS	NEC	209			4.7E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8839
ESA	D4364C-20L	8K x 8	CMOS	NEC	60			1.4E-14	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8436
ESA	D4364C-20L	8K x 8	CMOS	NEC	209			9.7E-15	Feb-92			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8436
ESA	D4464C-15	8K x 8	CMOS	NEC					Sep-92	50	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8945
ESA	D4464G-15L	8K x 8	CMOS	NEC					Feb-92	33	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8622
ESA	EDH8832C10 KMHR	32K x 8	CMOS	EDI	50			1.8E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8652
ESA	EDH8832C100CL	32K x 8	CMOS	EDI	50			9.5E-14	Mar-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8936
ESA	EDH8832C100CL	32K x 8	CMOS	EDI	50			1.3E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8936
ESA	EDH8832C100CL	32K x 8	CMOS	EDI	100			9.3E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8936
ESA	EDH8832C-15JMHR	32K x 8	CMOS	EDI	50			1.8E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8738
ESA	EDI8806CB 35QB	8K x 8	CMOS	EDI	300			2.0E-12	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9103

TABLE 2
Proton SEE/Transient Compendium

8-Jun-99

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
ESA	EDI8810L 150DB	8K x 8	CMOS	EDI					Aug-94	209	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9033
ESA	EDI88128C100CM	128K x 8	CMOS	EDI	500			1.3E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9102
ESA	EDI88130H45CM	128K x 8	CMOS	EDI	300			2.5E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9111
ESA	HM1-6504-2	4K x 1	CMOS	HAR	60			<5.3E-15	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8222
ESA	HM1-6504-5	4K x 1	CMOS	HAR	60			<5.3E-15	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 7943
ESA	HM1-6504-9	4K x 1	CMOS	HAR	209			<8.4E-15	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8508
ESA	HM1-65162-2	2K x 8	CMOS	MHS	100			4.2E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8740
ESA	HM1-65162-2	2K x 8	CMOS	MHS	200			5.0E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8740
ESA	HM1-65162-2	2K x 8	CMOS	MHS	300			7.6E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8902
ESA	HM1-6516-9	2K x 8	CMOS	HAR	60			2.4E-14	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8313
ESA	HM1-6516-9	2K x 8	CMOS	HAR	100			1.5E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8313
ESA	HM1-65262-2	16K x 1	CMOS	MHS	100			3.5E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8714
ESA	HM1E-65664B-2	8K x 8	CMOS	MHS	50			<2.9E-14	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9114
ESA	HM1E-65664B-2	8K x 8	CMOS	MHS	300			1.5E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9114
ESA	HM6116P-3	2K x 8	CMOS	HTC	45			3.1E-14	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8638
ESA	HM6116P-3	2K x 8	CMOS	HTC	209			5.8E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8638
ESA	HM6116P-3	2K x 8	CMOS	HTC	500			3.6E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8638
ESA	HM62256P-10	32K x 8	CMOS	HTC	209			1.6E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8817
ESA	HM62256P-10	32K x 8	CMOS	HTC	500			2.9E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8817
ESA	HM6264ALP-15	8K x 8	CMOS	HTC	100			1.2E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8901
ESA	HM6264LP-15	8K x 8	CMOS	HTC	45			3.9E-14	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8413
ESA	HM6264LP-15	8K x 8	CMOS	HTC	100			1.2E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8413
ESA	HM6264LP-15	8K x 8	CMOS	HTC	500			2.9E-13	Apr-93			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8413
MMS	HM628128BLP-7	128K x 8	HiCMOS, 0.8 μm features, Rev B.	HTC	18			3.0E-14	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68. D/C 9713
ESA	HM628128L-10	128K x 8	CMOS	HTC	500			1.0E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9009
ESA	HM628128L-10	128K x 8	CMOS	HTC	300			9.0E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9009/35
MMS	HM628512ALP-7	512K x 8	HiCMOS, 0.5 μm features, Rev B.	HTC	10			1.0E-13	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68. D/C 9705
ESA	HM628512P-7	128K x 8	CMOS	HTC	300			2.3E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9235
ESA	HM-65656	32K x 8	CMOS	MHS	300			3.9E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C (sample)

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
ESA	HM-65656E	32K x 8	CMOS	MHS	33			1.6E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C (sample)
ESA	HM65687E	64K x1	CMOS	MHS	100			1.4E-14	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C (sample)
ESA	HM-65697	256K x 1	CMOS	MHS	300			4.0E-13	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C (sample)
ESA	HMCE-65664B-8	8K x 8	CMOS	MHS	100			3.9E-14	Apr-91			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9232
ESA	IDT71256 9BC	32K x 8	CMOS	IDT	500			2.4E-13	Apr-89			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8943
ESA	IDT71256 OC	32K x 8	CMOS	IDT	500			2.9E-13	Apr-89			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9103BI
ESA	IDT7164	8K x 8	CMOS	IDT	50			2.9E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C RE9101BI
ESA	IDT7164	8K x 8	CMOS	IDT	500			1.7E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C RE9101BI
ESA	IMS1600S55 ABF	64K x1	CMOS	ISM	100			5.1E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8534
MMS	IS61C1024-20M	128K x 8	CMOS (0.5 μm)	ISS	10			2.0E-13	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68.
ESA	KM681000LP-8	128K x 8	CMOS	SAM	300			3.0E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 214Y
ESA	KM6840000LP-5	128K x 1	CMOS	SAM	300			2.0E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 310Y
MMS	KM864002AJ-17	512K x 8	CMOS/epi, 0.5 μm feature, Rev A	SAM	14			4.0E-16	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68.
ESA	M5M53568BP-15	32K x 8	CMOS	MIT	50			6.0E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9271
ESA	MAS6116	2K x 8	CMOS	MMS	100			3.0E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8737
ESA	MAS6116	2K x 8	CMOS	MMS	200			<2.0e-15	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8737
ESA	MB81C81A-45	256K x 1	CMOS	FUJ	500			1.6E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8820
ESA	MB84256-10L	32K x 8	CMOS	FUJ	800			5.0E-13	Mar-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8948
ESA	MB84256-10L	32K x 8	CMOS	FUJ	500			3.7E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8948
ESA	MB84256-15L	32K x 8	CMOS	FUJ	500			4.7E-15	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8650
ESA	MB8464-15	8K x 8	CMOS	FUJ	209			3.7E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8431
MMS	MCM6246WJ20	512K x 8	CMOS/epi, 0.5 μm feat., Rev W51.	MOT	8			3.0E-14	1997			PSI	Poivey, et al, 98IEEE Workshop Record, pg 68. D/C 9602
ESA	MM1-6504H11	4K x 1	CMOS	MHS	60			1.0E-14	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8619
ESA	MM1-6504H11	4K x 1	CMOS	MHS	100			9.0E-14	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8619
ESA	MSM8128S-70	128K x 8	CMOS	MPC	300			1.5E-14	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9210
ESA	MSM8128S-85	128K x 8	CMOS	MPC	300			8.4E-14	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9252
ESA	MSM8128SLMB-45	128K x 8	CMOS	MPC	300			3.4E-15	Apr-93			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9108
ESA	MSM8128SLMB-45	128K x 8	CMOS	MPC	300			1.1E-14	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9108
ESA	MT5C1008C-25	128K x 8	CMOS	MCN	500			2.8E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9110

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 8-Jun-99
ESA	MT5C256 S12D	32K x 8	CMOS	MCN	200			2.3E-15	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 1993(?)
ESA	MT5C2568 S02A	32K x 8	CMOS	MCN	30			9.0E-14	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9231
ESA	MT5C2568 S02A	32K x 8	CMOS	MCN	300			1.4E-14	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9231
ESA	P4C1257-35CC	256K x 1	CMOS	PFS	500			9.4E-15	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8943
ESA	QS83280-15P	32K x 8	CMOS	QSI					Aug-94	30	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9302
ESA	SMJ61CD16LA-25	16K x 1	CMOS	TIX					Nov-89	209	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8904
ESA	TC551001BPL-70L	128K x 8	CMOS	TOS	60			1.0E-14	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9623
ESA	TC551001BPL-70L	128K x 8	CMOS	TOS	60			7.0E-14	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9623
ESA	TC5516AP-2	2K x 8	CMOS	TOS	100			5.9E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8333
ESA	TC5516AP-2	2K x 8	CMOS	TOS	500			1.6E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8333
ESA	TC5516AP-2	2K x 8	CMOS	TOS	45.4			4.1E-15	Jun-89			VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8340
ESA	TC55257P-10	32K x 8	CMOS	TOS	209			1.0E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8640
ESA	TC5564PL-15	8K x 8	CMOS	TOS					Jun-89	60	<1.0E-13	VEC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8514
ESA	TC5564PL-15	8K x 8	CMOS	TOS					Nov-89	209	<1.0E-13	PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8646
ESA	TC55B8128P-20	128K x 8	CMOS	TOS	300			2.1E-13	May-96			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9230
ESA	UM62256-10L	32K x 8	CMOS	UTM	300			1.8E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9036
		Flash Memories											
ESA	AM29LV800B-120	1M x 8	CMOS	AMD	60			6.0E-18	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9625. V_{DD} = 3.3, Read mode.
ESA	CAT28F010P-15 OES	128kK x 8	CMOS	CAT	300			<8.8E-17	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9213. Read mode.
ESA	M28F101-150PI VP8	128kK x 8	CMOS	SGS	300			<8.8E-17	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9344. Read mode.
ESA	M28F256-15B1 VP8A	32K x 8	CMOS	SGS	300			<3.5E-16	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9309. Read mode.
ESA	M5M28F101P-12	128kK x 8	CMOS	MIT	300			<8.8E-17	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 312107. Read mode.
ESA	P28F010-120	128kK x 8	CMOS	INT	300			<7.6E-17	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C U13602P1. Read mode.
ESA	P28F512-120	64K x 1	CMOS	INT	300			<1.5E-16	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C U10938P2. Read mode.
ESA	TMS28F512-120C3NL	64K x 1	CMOS	TIX	300			<1.8E-16	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9331. Read mode.
		DRAMs											
GSFC	μPD4216400-60	4M x 4	CMOS (5.0 V)	NEC	197			7.8E-12	1996			IUCF	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	0116400J1C-70	4M x 4 (5.0 V)	CMOS	IBM	63	2.0E-07			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell errors.
GSFC	0116400J1C-70	160 Mbit stack (5.0 V)	CMOS	IBM	197				1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. No errors.
GSFC	0116400J1D	4M x 4 (5.0 V)	CMOS	IBM	63			1.5E-15	1996			UCD	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit and block errors.

TABLE 2

Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
GSFC	0116400J1D	4M x 4 (3.3 V)	CMOS	IBM	63			1.5E-15	1996			UCD	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit and block errors.
GSFC	011640PT1C-70	4M x 4 (3.3 V)	CMOS	IBM	63	2.0E-09			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell and block errors.
ESA	0117400BT1E-60	4M x 4 (3.3 V)	CMOS (IBM - ES3)	IBM	15			1.5E-15	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	0117400BT1F-60	4M x 4 (3.3 V)	CMOS (IBM - ES4)	IBM	11			9.0E-16	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	014400MJ1D	4M x 1	CMOS	IBM	300			2.1E-15	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9314
GSFC	4216400-70	4M x 4 (5.0 V)	CMOS	NEC	63	5.0E-07			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell errors.
GSFC	43G9240	4M x 4 (3.3 V)	CMOS	IBM	63	6.0E-09			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell and block errors.
ESA	4C4001JC-00E	4M x 1	CMOS	MCN	300			7.4E-14	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9244
ESA	63F9221 N13226TC	4M x 4	CMOS	IBM	300			<4.8E-19	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9314. Row/Column/Block Errors.
ESA	8116100-60PJ T32	16M x1	CMOS	FUJ	300			2.3E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9305
GSFC	8813045PC	128K x 8	CMOS	HTC	63			1.7E-13	1996			UCD	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
ESA	D421000C-10	1M x 1	CMOS	NEC	209			7.3E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8839
ESA	D4216100V-70	16M x1	CMOS	NEC	300			4.7E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9249
GSFC	D4216400G3-70	4M x 4 (3.3 V)	CMOS	NEC	63	2.0E-07			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell errors.
ESA	D424100V-80	4M x 1	CMOS	NEC	500			4.1E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9005
ESA	D424256C-80	256K x 4	CMOS	NEC	209			8.9E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8923
ESA	D424256V-80	256K x 4	CMOS	NEC	500			1.2E-12	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8919
ESA	EDI44102C 100ZC	4M x 1	CMOS	EDI	500			4.6E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9110
ESA	HM5116100Z8	16M x1	CMOS	HTC	300			3.5E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9228. Stuck bit @ 51 MeV.
GSFC	HM5116400AJ7	4M x 4	CMOS (5.0 V)	HTC	63	2.0E-07			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Cell errors.
ESA	HM5116400Z8	4M x 4	CMOS	HTC	300			4.0E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9233. Stuck bit @ 300 Mev
ESA	HM5116500AS6	4M x 4	CMOS	HTC	200			1.3E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9402. Stuck bit @ 100 MeV.
ESA	HM514100ZP8	4M x 1	CMOS	HTC	300			6.4E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9010
ESA	HM51W16100B	4M x 4 (3.3 V)	CMOS	HTC	11			1.5E-14	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	HYB511000A-70	1M x 1	CMOS	SIE	209			4.0E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8846
ESA	HYB514100J-10	4M x 1	CMOS	SIE	500			3.5E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 008
ESA	HYB514256-70	256K x 4	CMOS	SIE	500			1.2E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9028
ESA	IBM401070804 5352	4M x 4	CMOS	IBM	200			8.0E-13	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9237. 1 Block Error @ 200MeV.
ESA	KM41C16000J-7	16M x1	CMOS	SAM	300			4.4E-14-4.8E-14	1994			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 311

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 8-Jun-99
ESA	KM41C4000J-8	4M x 1	CMOS	SAM	500			7.8E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 019
ESA	KM44V4100AJ	4M x 4 (3.3 V)	CMOS	SAM	10			5.0E-14	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	KM44V4100B	4M x 4 (3.3 V)	CMOS	SAM	10			2.0E-14	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
GSFC	KM48V8100AS-16	8M x 8	CMOS	SAM	63			1.0E-14	1996			UCD	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
HON	KM48V8100AS-16	8M x 8	CMOS	SAM	~63	4.0E-07			Jun-98			UCD	Ash, et al, 1999 COTS Workshop Proceedings, pg 287.
ESA	LUNA ES/3	4M x 4	CMOS	IBM	60			3.0E-17	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none. V_{DD} = 4.5 V.
ESA	LUNA ES/3	4M x 4	CMOS	IBM	60			1.9E-16	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none. V_{DD} = 3.3 V.
GSFC	LUNA-ES Rev C	4M x 4	CMOS/epi	IBM					1997			var.	O'Bryan, et al, 98IEEE Workshop Record, pg 39. Bit, pointer & functionality interrupt errors
ESA	M515100-80J 9A9Z	4M x 1	CMOS	OKI	500			8.2E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9010
ESA	M5M44C256P	256K x 4	CMOS	MIT	209			2.7E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8662
ESA	M5M4C1000P	1M x 1	CMOS	MIT	209			3.1E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 7152E2-12
ESA	MBB14100-10PSZ	4M x 1	CMOS	FUJ	500			1.7E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9025
ESA	MCM514100Z80	4M x 1	CMOS	MOT	500			2.3E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8951
ESA	MT4C1004C	4M x 1	CMOS	MCM	500			9.1E-14	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9102
ESA	MT4C4001 DO2A	4M x 1	CMOS	MCM	300			7.3E-14	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9236C
ESA	MT4CM4B1DW	4M x 4	CMOS	MCN	300			3.1E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9406B
ESA	MT4LC4001 D22	4M x 1	CMOS	MCM	200			2.1E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none. 200-300 MeV 1 Row Error
ESA	MT4LC4M4B1DJ-6	4M x 4 (3.3 V)	CMOS	MCN	14			1.5E-14	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	MT4LC4M4E8TG	4M x 4 (3.3 V)	CMOS	MCN	11			8.0E-15	1997			PSI	Harboe-Sorensen, et al, 98IEEE Workshop Record, pg 74.
ESA	MT4LC4MB1D28M	4M x 4	CMOS	MCN	60			2.7E-15	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none. V_{DD} = 4.5 V.
ESA	MT4LC4MB1D28M	4M x 4	CMOS	MCN	60			4.9E-15	Nov-96			CYC	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none. V_{DD} = 3.3 V.
GSFC	MT5C1880CW-25	128K x 8 (5.0 V)	CMOS	MCN	63			4.8E-17	1996			UCD	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
GSFC	SMJ44100	4M X 16 EDO (5.0 V)	CMOS/epi	TIX	<25			3.5E-13	1992			SAT	Duzellier, et al, 93IEEE TNS preprint (not published). D/C ES. Also has proton data.
ESA	SMJ4C1024-12JDM	1M x 1	CMOS	TIX	209			4.7E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8840
ESA	SMX44100-80HLM	4M x 1	CMOS	TIX	300			2.6E-13	May-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9218 B
ESA	TC511000AP-10	1M x 1	CMOS	TOS	209			3.7E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8748
ESA	TC5116400J-60	4M x 4	CMOS	TOS	300			1.6E-13	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9334MCD
ESA	TC514100Z-10 HDK	4M x1	CMOS	TOS	500			2.3E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 9007

TABLE 2
Proton SEE/Transient Compendium

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks 8-Jun-99
ESA	TC514256P-10	256K x 4	CMOS	TOS	209			3.9E-13	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8811
ESA	TMS416400A	4M x 4	CMOS	TIX	300			3.7E-14	Aug-94			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C none.
GSFC	TMS416400DJ-60	4M x 4	CMOS	TIX	197			5.4E-12	1996			IUCF	LaBel, et al, 97IEEE Workshop Record, pg 14. Bit errors.
ESA	TMS44100DM-80	4M x 1	CMOS	TIX	500			2.2E-13	Apr-91			SAT	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 0485
ESA	TMS4416-12NL	16K x 4	CMOS	TIX	209			1.4E-12	Nov-89			PSI	Harboe-Sorensen, RADECS97 Data Workshop, pg. 89. D/C 8844
GSFC	TP0116400AJ3B-70	4M x 4	CMOS	IBM	63	6.0E-09			1995			UCD	LaBel, et al, 96IEEE Workshop Record, pg 19. Bit errors and one block error.
		Microprocessor (32-bit)											
SEI	80486DX2RP		CHMOS V (0.8 μm)	INT	63	1.0E-09			1997			UCD	Layton, et al, 98IEEE Workshop Record, pg 170.D/C 9527527C. Cross section with cache on. No SEU with cache off.
JPL	K5-PR166ABX	Pentium	CMOS (3.5 V)	AMD	195				Jun-97		5.6E-09	IUCF	Miyahira, Preliminary JPL Report.
		Optocouplers											
GSFC	62123	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. SETs but shows CTR degradation.
GSFC	66088	Optocoupler		MPC	63				1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	66099	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	4N48	Optocoupler		OPT	63				1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	4N49	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs or CTR degradation.
GSFC	4N55	Optocoupler		HPA	63				1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	6N136	Optocoupler		MPC	63				1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. D/C 9707. No SETs observed @ 4.5 V and bias off.
GSFC	6N140	Darlington Amplifier	700 μm (GaAsP) sandwich	MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs observed.
GSFC	6N140A	Darlington Amplifier	700 μm (GaAsP) sandwich	HPA	63				1997			BNL	O'Bryan, et al, 98IEEE Workshop Record, pg 39. D/C 9707. No SETs observed.
GSFC	HCPL-5401	Optocoupler		HPA	63	8.5E-08			1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. 20-25 ns SETs observed with device unbiased.
GSFC	HCPL-5631	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	63	3.5E-08			1997			UCD	LaBel, et al, 97IEEE TNS, Vol. 44, No. 6, pg 1885. D/C9247 & 9707.
GSFC	HCPL-5631	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	38.2	4.5E-08			1997			UCD	LaBel, et al, 97IEEE TNS, Vol. 44, No. 6, pg 1885. D/C9247 & 9707.
GSFC	HCPL-5631 (6N134)	Hi-Gain Amp.	700 μm (GaAsP) sandwich	HPA	var.				1997				O'Bryan, et al, 98IEEE Workshop Record, pg 39. SETs observed.
GSFC	HCPL-6651	Optocoupler		HPA	220	1.0E-08			1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. SETs observed.
GSFC	HCPL-6651	Optocoupler		HPA	70	1.0E-07			1997			ICUF	O'Bryan, et al, 98IEEE Workshop Record, pg 39. SETs observed. No CTR degradation. Cross section @ 90°.
GSFC	HCPL-6651	Optocoupler		HPA	58	1.0E-07			1997			TRI	O'Bryan, et al, 98IEEE Workshop Record, pg 39. No SETs or CTR degradation with active or passive filters. SETs but no CTR degradation without filters..
GSFC	HSSR-7110	Power MOSFET Optocoupler	AlGaAs LED; n-channel MOSFET	HPA	var.								LaBel, et al, EEELinks, Vol. 3, No. 1, pg 5, Mar 1997. No SEE.
GSFC	SEDA	1773 1MHz F/O Bus		SCI	63				1997			UCD	O'Bryan, et al, 98IEEE Workshop Record, pg 39. Proton-induced SEUs.
		Voltage Comparators											
JPL	LM139	Quad	Bipolar	NSC	200	3.2E-11			Feb-96			IUCF	Transients only. +25mV input delta.

TABLE 2
Proton SEE/Transient Compendium

8-Jun-99

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (cm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
JPL	LM139	Quad	Bipolar	NSC	200	1.2E-10			Feb-96			IUCF	Transients only. +25mV input delta.

Legend:

Manufacturers: ACT - ACTEL, Corp; ADA - Advanced Analog Devices; AMD - Advanced Microdevices Corp; ASI - Allied Signal, Inc; ATT - American Telephone & Telegraph; CYP - Cypress Corp; EDI - EDI Corp; FOR - Force, Inc; FUJ - Fujitsu, Ltd; HAR - Harris, Corp; HPA - Hewlett-Packard; HTC - Hitachi, Ltd; IBM - International Business Machines; IDT - Integrated Device Technology; INT - Intel Corp; ISM - Inmos, Corp; ISS - ISS, Inc; MAT - Matsushita; MCN - Micron Technologies; MHS - Matra-Harris Semiconductor (France); MIT - Mitsubishi; MOT - Motorola Semiconductor Products; MPC - Micropac, Corp; NEC - Nippon Electric Corp; NSC - National Semiconductor; PFS - Performance Semiconductors; QSI - Quickswitch, Inc; SAM - Samsung; SIE - Siemens Components, Inc; SNY - Sony Corp; TIX - Texas Instruments; TOS - Toshiba; UTM - United Technologies Microelectronics Center;

Test Houses

GSFC - Goddard Space Flight Center, Greenbelt, MD
ESA = European Space Agency, Noordwijk, Netherlands
HON = Honeywell Space Systems, Clearwater, FL
JPL = Jet Propulsion Laboratory, Pasadena, CA
MMS - Matra Marconi Space, France
SAAB - Ericsson Saab Avionics AB, Linköping, Sweden
SEI - Space Electronics, Inc, San Diego, CA

Radiation Facilities:

BNL - Tandem Van de Graaff, Brookhaven National Laboratories, Long Island, NY
CYC - CYCLONE, Université Catholique de Louvain-la-Neuve, Belgium
IUCF - Indiana University Cyclotron Facility, Bloomington, IN
PSI - Paul Scheerer Institute, Villigen, Switzerland
SAT - SATURNE, CEA, Saclay, France
TRI - TRI-University Meson Facility, Vancouver, British Columbia, Canada
UCD - University of California at Davis, Crocker Nuclear Laboratory, Davis, CA
VEC - Variable Energy Cyclotron, AERE, Harwell, UK

Table 3
Proton Displacement Damage

26-Apr-99

Test Org.*	Device	Function	Technology	Mfr.	Proton Energy (MeV)	Device Xsection (cm^2)	Bits Tested	Bit Xsection (μm^2)	Test Date	LU_{th}	LU Xsection (cm^2)	Fac.	Remarks
		DAC (8-bit)											
GSFC	DAC 08		Bipolar	ADI PMI	58				1997			UCD	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. I_{il} & I_{ref} out of spec @ 30krads.
GSFC	DAC 08		Bipolar	RAY	59				1997			UCD	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. No parameters out of spec @ 30 krads.
		DC/DC Power Converters											
GSFC	MHF+2805S	Single output, +5 V	Hybrid	ADA	51				1997			LLU ICUF	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. D/C 9616. Ceased regulating @ 4.4E10 p/cm^2 (~7 krads).
GSFC	MHF+2812D	3-Output, +5 V, +12 V.	Hybrid	ADA	51				1997			LLU ICUF	O'Bryan, et al 98IEEE Wrkshp Rec., pg 39. D/C 9603. Ceased regulating @ 4.4E10 p/cm^2 (~7 krads).
		Optocouplers											
GSFC	62123	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. Shows CTR degradation and some SETs.
GSFC	66088	Optocoupler		MPC	63				1997			UCD	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation or SETs.
GSFC	66099	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation or SETs.
GSFC	4N49	Optocoupler		MPC	58				1997			TRI	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation or SETs.
GSFC	HCPL-6651	Optocoupler		HPA	220	1.0E-08			1997			TRI	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation. SETs observed.
GSFC	HCPL-6651	Optocoupler		HPA	70	1.0E-07			1997			ICUF	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation. SETs observed. Cross section @ 90°.
GSFC	HCPL-6651	Optocoupler		HPA	58	1.0E-07			1997			TRI	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No CTR degradation or SETs with active or passive filters. SETs but no CTR degradation with no filter.
GSFC	P2824	Optocoupler		HAM	51.8				1997			LLU	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. CTR degraded below specification with drive current < 7.2 mA at 6E10 p/cm^2.
GSFC	P2824	Optocoupler		HAM	195				1997			IUCF	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. CTR degraded below specification for all drive currents (max. 12.1 mA) at ~1.5E11 p/cm^2.
		Other Linears											
GSFC	PFORX12	Data Transmission Receiver		ONI	62.5				1997			UCD	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No bit errors up to 30 krads. Error bursts at 85 krads.
GSFC	PFOTX12	Data Transmission Xmtr		ONI	62.5				1997			UCD	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. No bit errors up to 30 krads. Error bursts at 85 krads.
		Voltage References											
GSFC	REF-43	2.5 V Reference.	Bipolar	ADI	var.				1997			var.	O'Bryan, et al, 98IEEE Wrkshp Rec., pg 39. V_{ref} sensitivity @ 20-30 krads.

Legend:

Manufacturers: ADA - Advanced Analog Devices; ADI - Analog Devices, Inc; HAM - Hamamatsu; HPA - Hewlett-Packard; MPC - Micropac, Corp; ONI - Optical Networks, Inc; PMI - Precision Monolithic, Inc; RAY - Raytheon

Test House:
GSFC - Goddard Space Flight Center, Greenbelt, MD

Radiation Facilities:
IUCF - Indiana University Cyclotron Facility, Bloomington, IN
LLU - Loma Linda University Medical Center, Loma Linda, CA
TRI - TRI-University Meson Facility (TRIUMF), Vancouver, British Columbia, Canada
UCD - University of California at Davis, Crocker Nuclear Laboratory, Davis, CA